THE GEOLOGY OF THE GLASS HOUSE MOUNTAINS AND DISTRICT.

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(Plates xlvi.-l.)

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i. Introduction.

The Glass House Mountains form a group of conical heights, scattered over a lenticular area whose centre is roughly forty-four miles north of Brisbane, S. Queensland. In this paper it is proposed to discuss, as well as the Glass House Mountains themselves, that portion of the East Moreton District in which they are situated. It comprises the parishes of Beerwah, Toorbul, Canning and Durundur, a few features of some other neighbouring parishes being also touched upon.

The Glass House Mountains were discovered and named by Captain Cook in May, 1770,* and again noticed by Flinders in July, 1802.† They owe their name to their resemblance to glass houses, when viewed from Moreton Bay on a fine day after a shower. No one has so far ever made a systematic geological examination of them, our knowledge up to the present being derived from scattered notes of various geologists who rapidly toured the district. In the present paper I propose to give the results of over three weeks' field work in the mountains themselves, supplemented by a considerable amount of petrological work on the specimens collected, carried out in the geological laboratory of the University of Sydney. Having been a resident of Caboolture, near the Glass House Mountains, for ten years, I have had the additional advantage of being thoroughly acquainted with the entire district.

ii. Bibliography.

The first geological record of the Glass House Mountains is that of Mr. Stutchbury, who, in 1854, described them as consisting of masses of metamorphic sandstone, left standing after the unaltered sandstone had been removed by denudation.‡

In 1875, the Hon. A. C. Gregory referred to them as "*outbursts of porphyry.*"§

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* Hawkesworth, J., "Account of the Voyages," &c. Vol. iii., 1773 [Cook's First Voyage, 1768-71].

† "A Voyage to Terra Australis in H.M.S. The Investigator." Vol. ii., p. 6, 1814.

‡ Jack and Etheridge, Geology and Palæontology of Queensland, p. 73, and bibliography there given.

§ Report on the Geology of Part of the Districts of Wide Bay and Burnett. Brisbane; Govt. Printer, 1875.

In 1888, the Rev. J. E. Tenison Woods, F.L.S., read a paper before the Royal Society of New South Wales on the "Desert Sandstone." With this paper he published plates illustrating what he terms "Prismatic Basalt, Glass House Mountains," and in the text he states that the "Glass House Mountains appear to be of the same age as a basaltic flow at Lytton, a few miles inland from Cleveland." In the same paper the author refers to the conglomerates and sandstones in the Moreton District as "Desert Sandstone"; and he remarks "that only a few fragments of coniferous wood have been found imbedded in it, proving nothing as regards age."

In a descriptive account of the Glass House Mountains in the 'Queensland Railway and Tourists' Guide,' compiled under instructions from the Queenland Railway Commissioners, the author, Mr. A. Meston, refers to the geology of the mountains, and perpetuates the old notion that they are composed of sandstone, and rise out of the Cretaceous formation.

In Appendix ii. of Jack and Etheridge's 'Geology and Palæontology of Queensland,' we read:—"Recently Mr. Henry G. Stokes has presented to the Geological Survey a series of specimens gathered in the Mountains themselves (*i.e., the Glass House Mountains**), from which it appears that the staple rock is trachyte."

Mr. Stokes has since read a paper in which he further points out the intrusive character of the trachytes.†

Mr. E. C. Andrews, B.A., in a paper, "Preliminary Note on the Geology of the Queensland Coast, &c.,"‡ speaks of the Glass House Mountains as "monadnock-like" heights, which rise from a coastal plain. Mr. Andrews also considers this coastal "*plain*" or "*flat*" to be due to the redistribution by tidal action of fluviatile material.

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* The italics are mine.

† Trans. Nat. Hist. Society of Queensland, Vol. i., 1892, 3-4.

‡ Proc. Linn. Soc. N.S. Wales, 1902.

iii. Physiography and Topography.

(*a*) *Undulating Sandy Country.*—The coastal tract from which the Glass House Mountains rise as isolated peaks, consists of gently undulating country, which appears a "*plain*" or "*flat*" when viewed from the sea. It is covered with a sandy soil sustaining a forest vegetation consisting of Eucalypts (white-gum, blue-gum, red-gum, stringy-bark, cabbage-trees, ironbark), Tea-trees, Banksia, Casuarina, Callistemon and Xanthorrhœa. The grasses are poor. In the sour-soiled, swampy flats the grass-tree (Xanthorrhœa) never produces a trunk as on the ridges. Near the trachytic peaks themselves the sandy soil gives place to a grey, ash-like soil, which is even more incapable of supporting healthy vegetation, inasmuch as it becomes sour in wet seasons from want of drainage, and cakes in dry weather.

This kind of country extends from Deception Bay on the east to the outcrop of the Palæozoic rocks on the west. The Palæozoic rocks are met with about seven miles west of Caboolture; here their junction line with the Mesozoic takes a north-westerly trend so that they are only reached in fifteen or sixteen miles going due west from the Glass House Mountains Station, which is fourteen miles north of Caboolture, and about forty-six miles north of Brisbane. The D'Aguilar Range, which forms the watershed between the coastal streams and the Stanley River (a tributary of the Brisbane River) basin, consists at Mt. Mee of Palæozoic rocks; but from the vicinity of Delaney's Creek northwards it becomes a mere sandstone ridge, whose constituent rocks are of Mesozoic age.

The Palæozoic rocks of Mt. Mee and neighbourhood consist of slates, schists, phyllites, granites and diorites with veins of quartz intersecting the sedimentary rocks, and dykes of gneiss, syenite, hornblende rock and gabbro intersecting the granites. Many of the quartz veins and leaders, and several of the dykes are metalliferous.

The sandy soil of the coastal tract overlies and is probably derived from the subaerial denudation of a formation consisting of interbedded sandstones, shales and conglomerates, which is apparently continuous and identical with the Ipswich and Burrum Coal Measures. This formation is devoid of fossils excepting the very abundant silicified wood and a few ill-preserved leaves. In this paper it will be termed the Coal Measure Formation, identical with the Trias-Jura of Jack.

The above-mentioned Palæozoic rocks are put down by Jack as "Gympie Formation," but they may be much older. No fossils have as yet been found in them.

The rocks of the Coal Measure Formation are not horizontally bedded. On the contrary, they dip at varying angles, and form small anticlines and synclines. In places trachyte intrusions have served to bring about this result. The northern part of the D'Aguilar Range bears every appearance of being an anticlinal fold. This part of the range (lying north of Steep Hill) is between 500 and 800 feet in average height, and is composed of sandstones and conglomerates of the Coal Measure Formation, which do not present to the eye signs of great erosion, such as steep cliffs and escarpments, a feature so noticeable in the Hawkesbury formation of the Sydney basin. The strata dip (as far as my observations go) away from the summit of the range Towards Peachester, west of the range, sandy soil overlying sandstone occurs as on the east. The same formation continues northwards to the Blackall Ranges, where it has been fissured and partly covered by flows of basalt. The sandstones differ greatly in colour and texture, ranging from fine argillaceous sandstones to coarse conglomerates, and varying in colour from white to red. Some varieties are highly ferruginous, becoming a "sand-ironstone." Interbedded with them I have found white clay shales, as at Mewett's Mountain, near the Six-Mile Creek, and also near Mt. Tunbubudla, black carbonaceous shale in the bed of the Six-Mile Creek, about a quarter of a mile east of the railway line, and coarse conglomerates near Mt. Beerwah. Coal is said to occur to the north west of Mt. Mellum; and also in several places in the Stanley River basin, south of the Blackall Range.

In the sandy country, swampy tracts are abundant. East of the D'Aguilar Range they seem to mark the position of old water-courses. The Lagoon Creek marks the position of an old water-course, the greater part of whose drainage area has now been captured by the Caboolture River. The swamps contain deep black, peaty soil, consisting of matted vegetable matter, logs, &c., beneath which there is a floor of sandstone, sand and gravel, or clay. The lagoons or ponds in the swamps quite commonly have sandstone floors and walls, this sandstone containing petrified wood similar to and as abundant as that obtained in the rocks of the D'Aguilar Range.

Along the Deception Bay Coast we meet with numerous shell banks, containing oyster shells, Pecten, Cerithium, *Arca antiquata* and other shells, some of these banks being over a mile from the shore. These may indicate that some elevation has taken place, but it is perhaps more likely that they mark the old shore-line, land-resumption slowly taking place through tidal action. However there are grounds for believing that some elevation has taken place in recent times, some of the hills fronting the N.W. corner of Deception Bay having the appearance of true raised beaches. The sand banks more than two miles from the shore-line are certainly of wind-blown origin, containing no marine remains. These banks are, in my opinion, not river drift, the sand grains being too fine and even-sized to have a fluviatile origin.

Land-resumption by the action of the sea and organised life combined is at present going on in Moreton Bay; the coastal alluvium may, therefore, consist of old shore-banks rendered terra firma by the gradual recession of the sea, and many of the salt marshes along the coast may represent little inlets and mouths of creeks, resumed in this way. (See Part vi., Notes by H. L. Kesteven).

(*b*) *The Glass House Mountains.*—These mountains are situated on an elliptical area, having its long axis north and south. The centre of the area is about 44 miles N. of Brisbane. They all rise very sharply out of the Coal Measure sandstone, their summits being either quite bare or only scantily decorated with a few dwarf gums, orchids and mosses. Mt. Beerwah, the loftiest cone of the group, is only 1,760 feet high; Mt. Conowrin 1,170 feet; Mt. Tunbubudla 1,020; all the others being below 1,000 feet. They are all of a steeply conical, sugarloaf form, composed of trachyte which is for the most part columnar. The most southerly member of the trachyte cones that I have been able to find is the Round Mountain, a hill about three miles W. of Caboolture; the most northerly, Coochin Mountain, near Beerwah Railway Station.

Those mountains which rise directly from level country, *e.g.*, Tibrogargan, Tunbubudla, and Miketeebumulgrai, are surrounded by a gutter of boggy country, a few hundred yards wide, round which a sandy ridge, often with sandstone outcrops, is met with. This gutter, which is studded with "paddymelon" holes, may be due to a slight subsidence caused by the weight of the mountain, perhaps accompanied by faulting (a cauldron fracture), or it may be due to the wash of water down the steep sides of the mountain in rainy seasons.

(*c*) *Miscellaneous Notes on Physiography.*—A noticeable feature in the East Moreton district is the close correspondence between vegetation and geological formation.*

On the sandstone formation, oaks (Casuarina) are very plentifully distributed amongst the gums, and the grass-trees have trunks.

Where the soil is clayey, overlying shale, wattles are interspersed amongst tall straight gums and stringybarks.

On the ashy, caking soil from decomposing trachyte, vegetation is very scanty, consisting of crippled tea-trees and stemless grass-trees *(Xanthorrhœa)*. On the trachyte formation oaks are typically absent, but often a trachyte dyke is marked by a row of tall gums and oaks, which have here sufficient food as well as good drainage.

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* *Cf.* Mr. Maiden's Presidential Address to the Linnean Society of New South Wales, Proc. 1902, p. 682.

The basalt country (Mt. Mellum, Blackall Ranges, &c.) is invariably covered by dense scrub, containing numerous palms, tree-ferns, bamboos, canes, &c. The andesite tracts sustain chiefly large Eucalypts, which are remarkable for their crookedness on this formation.

In the slate country, both scrub and forest vegetation is present, the former along the valleys, the latter on the ridges. Moreton Bay figs, nettle-trees, canes and the so-called wild chestnuts are abundant, but few palms. Excellent timber, both pine and hardwood, is procured here. Cedar is more plentiful on basaltic soil.

Along the coast box-trees are abundant, and the shore banks usually sustain some Casuarina and bread-fruit trees, whilst growing in the water, mangrove thickets are of frequent occurrence.

In Mr. Andrews paper,* it is stated that:—"In the coastal regions one finds a few feet beneath the sand a sort of pipeclay, with ironstone nodules, extending to great depth." This statement is not strictly correct as far as my observations extend. Several wells have been examined to ascertain the succession of strata under the sandy soil. As a rule, after passing through the surface soil or sand, we reach a white or yellow clay, at a depth of two or three feet. This clay may have a thickness of from one to perhaps twenty feet; if thin, we usually find beneath it a layer of ironstone pebbles a few inches in thickness, and then sandstone, with or without the intermission of another clay band; if thick, there are several gravel and pebble bands in the clay, as was observed in a well on our own homestead, near Caboolture.

The pebbles of these bands are imbedded in a sandy clay, and have a rounded appearance as if water-worn. In places, particularly where intermingled with quartz gravel, they may be of fluviatile origin. On account of these pebbles a river drift theory of the origin of the East Moreton lowlands has been advanced. It has been suggested that the whole district has been in geolo-

* Proc. Linn. Soc. N.S. Wales, 1902, p. 149.

gically recent times a vast estuary into which a river flowed, depositing the above-mentioned clays and gravels. On account of the great variation in the thickness of the clay and pebble layers indicating their purely local development in places where small streams have formerly existed, as well as for other reasons already recorded, I cannot entertain "the river drift" theory. My observations on the formation of ironstone pebbles furthermore lead to a different conclusion.

Rounded ferruginous pebbles were found in great abundance under that grey ashy soil formed from decomposed trachyte or trachyte tuff. On breaking them a core of trachyte was frequently found. In the vicinity of Mt. Conowrin, Mt. Beerburrum, and Mt. Miketeebumulgrai trachyte in course of weathering has been observed to disintegrate into rounded lumps covered with a ferruginous crust. This is particularly the case with trachytes rich in deep blue pleochroic amphiboles. It seems, therefore, that, in many cases, the pebbles can be traced to the decomposition of trachyte or trachyte tuff; it is very probable that in early Tertiary times a great portion of the district was covered with loosely cemented volcanic ashes and bombs. In localities where ferruginous pebbles are in course of formation, the decomposing trachyte has a nodular or tuberculate appearance. These pebbles are nearly all less than half an inch in diameter.

Another source of ironstone pebbles and nodules (from $\frac{1}{2}$ to 3 inches in diameter) is the decomposition of the ferruginous sandstones of the Coal Measure Formation. In the sandstones, heavy ironstone concretions are abundant, and are left behind when the rock containing them has weathered away.

iv. Geology.

(1). *Structure and Origin of the Glass House Mountains.*—These mountains represent old volcanic plugs of trachytic lava which have forced their way into ancient tuff cones now denuded, or else have burst through fissures in the Coal Measure sandstone, reaching the surface in a very viscous state. In the latter case the viscous masses must have remained in the place where erupted, taking the form of mamelons.*

An inspection of the arrangement of the columns on Ngun Ngun and Tibrogargan clearly proves that the Glass House Mountains are not the remains of a huge lava sheet, as has been suggested by some. In most instances we see no evidence of the lava having flowed from the vent. At Mt. Ngun Ngun, however, very short lava flows have taken place.

The rock is typically trachyte. In some places it is so coarsely porphyritic as to become a felspar porphyry, as for example, the Mt. Beerburrum rock.

The felspar is universally of two generations, in phenocrysts often somewhat corroded, and in minute laths forming with ægerine the microcrystalline to cryptocrystalline base. Hence it is probable that the magma had already cooled and partly crystallised out at considerable depth, before it found vents and broke through to the surface.

The trachytic rocks are later than the sandstones (Ipswich-Burrum Coal Measures), as proved by the following facts:—

(1) The sandstones are traversed in various places by trachyte dykes.

(2) At the junction of the trachyte and sandstone the latter shows unmistakable signs of metamorphosis, such as hardening, induced crystallisation, and assumption of columnar structure.

(3) Small tongues of trachyte have been injected into the sandstones on the junction line.

(4) The sandstones have been disrupted and sometimes tilted at considerable angles by the trachyte. One good instance of this is afforded by an anticline caused by a trachyte dyke in a railway cutting about half a mile north of Beerburrum Station (Plate xlix., fig. 5). At Mt. Beerwah and Mt. Conowrin the sandstones dip away from the trachyte mass.

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* This is often the case with trachytic lavas. Compare the Puys of Auvergne, the phonolite hills of Bohemia, and the mamelons of the Isle of Bourbon. See "Volcanoes," by Judd, ch. v.

On the other hand, the trachytes are older than the other volcanic rocks of the district. There is evidence that basalt flows from Mt. Mellum have once extended to Coochin and covered trachytic rocks in that vicinity. The remarkable quartz-augite-hornblende andesite, which forms the surface rock at Grigor's place (Bankfoot House) contains abundant trachytic inclusions. Some of these inclusions, those obtained by me close to Bankfoot House, are analogous to the Beerwah trachyte; others, obtained at Mt. Bokay, close to Mt. Conowrin, consist of Conowrin trachyte.

The rock of the more rounded and less elevated members of the Glass House Mountain group is in general more basic than that of the steeper and higher mountains. The rock of Mt. Cooee, a hill lying a few hundred yards north of Mt. Tibrogargan, seems of very varying basicity, merging in places into a rock indistinguishable in hand specimens from the Bankfoot House andesite.

(2). *The order of eruption* seems to have been—

1. Tuffs like those of Trachyte Range.

2. Compact trachytes like those of Conowrin, Tibrogargan, Beerwah and Ewin.

3. More basic trachytes of Mt. Ngun-Ngun, Mt. Cooee, Mt. Beerburrum, Mewett's Mountain, and Medway's Mountain; trachytes containing much blue hornblende and ægerine.

4. Quartz andesites—the Bankfoot House formation.

5. Basalts, erupted at Mt. Mellum in the Blackall Ranges, and at Buderim Mountain.

(3). *Occurrence of Dykes.*—Dykes are abundant. On the main Gympie road, between Mt. Tunbubudla and Bankfoot House, one meets with a number of long narrow dykes running across the country in straight lines. They form a very noticeable feature, inasmuch as they can be seen at some distance and resemble artificial stone barricades when viewed from afar. The dykes met with on the main Gympie Road between Mt. Tunbubudla and Conowrin Creek all seem to radiate from the two Tunbubudla mountains (locally known as The Twins).

A very interesting dyke occurs on the western side of Mt. Conowrin, exposed by a landslip a few years ago.

The most conspicuous dyke in the district is, however, the one which has given rise to the anticline in the sandstones of a railway cutting half a mile north from Beerburrum Railway Station. This dyke has forced its way along a bed of shale interbedded with the sandstone, the lava having carried some of the shale before it in its path. The lava has seemingly come from the S.E., so that we get a mass of altered black shales, about 40 feet in thickness, exposed in section on the western flank of the cutting, whilst the original shale bed showing on the eastern flank has only a thickness of two or three feet at the most. On this side the trachyte dyke does not show. Evidently the lava has come diagonally upwards. (Plate xlix., fig. 5).

The finely crystalline nature of the dyke rocks, as well as their close resemblance structurally and mineralogically to the trachytes of adjacent peaks, seems to me to show that they are derived from the same source, and contemporaneous. From their texture it is evident that they consolidated near the surface, and hence it appears that the amount of denudation undergone by the Triassic rocks since the trachyte eruptions has been small.

(4). *Possible Laccolites.*—From Medway's Mountain on 58v Canning westward, an area including selections 2v, 58v and 86v has trachyte rock underlying the surface soil. The trachyte here is considerably more coarse-grained and more ferruginous than that which has found vent in Medway's Mt. On weathering, it turns brick-red. Along the right side of the Durundur road, which crosses selections 2v and 86v, a trachyte outcrop many chains in width and nearly a mile in length may be traced. It does not reach an elevation of more than 10 to 12 feet above the surrounding country. The rock weathers into huge boulders in much the same way as granite, and in mineral composition it is analogous to the trachyte of Mt. Beerburrum. Within a radius of half a mile from it the soil is very poor, ashlike and caking, typical of decomposing trachyte. This is probably a laccolitic mass which has consolidated under a bed of sandstone or loosely cemented tuff, the coarsely crystalline nature of the rock and the viscosity of trachytic magmas generally, supporting such a supposition. It could also be interpreted as a large dyke mass. It is probably not a flow from any of the adjacent trachyte mountains, the rock being macrocrystalline and porphyritic.

(5). *Occurrence of Tufaceous Rocks.*—The occurrence of undoubted tuffs is very rare. Tuffs *may* formerly have covered a large area and formed cones round the trachyte plugs, but must have been very loosely cemented. Hence it seems improbable that the Glass House Mountains were submarine volcanoes, submarine tuffs being usually fairly compact. The only undoubted tuffs observed were those of a ridge to the south of Mt. Tibrogargan which I have called the Trachyte Range.* At a spot on this ridge—Skeleton Cave, south of Mt. Ewin—where I discovered some aboriginal skeletons in a cave, pyroclastic rocks with large angular fragments occur. Some specimens obtained on Tibrogargan may be tufaceous, but have not yet been properly examined.

Trachyte Range is a low continuous ridge of trachyte (rising in some places to an altitude of 300-350 feet above the surrounding country). It runs from Mt. Beerburrum in the direction of Mt. Tibrogargan, taking, however, a westerly trend at a place to the S.S.E. of Mt. Ewin, and continuing almost to the Gympie road. The core of the ridge consists of compact trachytic lava similar to that of Mt. Ewin, and also very like that of Mt. Jellore, of which Mr. T. G. Taylor, of the Sydney University, has kindly shown me some sections. At various points, as at Skeleton Cave, tuffs occur, these forming a hard, greenish rock, emitting a ringing sound when struck. They have evidently been highly silicified. The entire ridge evidently marks an earth-fissure which has emitted lavas and tuffs. Probably siliceous hot springs

* The names, Trachyte Range, Skeleton Cave, Mt. Bokay, and Mt. Cooee, made use of in this paper, refer to localities which frequently require mention, but which have not as yet local names, nor do they bear names on the official maps.

have altered the tuffs here and rendered them capable of resisting denudation.

(6) *Occurrence and Structure of the Andesite Formation.*—This formation covers an area of about 500 acres lying S.E of Mt. Conowrin. The andesite assumes an irregular columnar structure in places, and has to some extent prismatised the underlying conglomerates. It is extremely variable in basicity, being in some places pale grey in colour, in others perfectly black; sometimes rather fine-textured, sometimes coarsely porphyritic. The amount of quartz varies considerably. Perhaps the name dacite will be found more appropriate than andesite. It is important that it contains trachyte inclusions, hence is later than the trachytes. The geburite-dacites of Mount Macedon, Vic., were found to be the earliest trachytic rocks erupted in that region, so the order of eruption is somewhat different in the Glass House Mountains and Mount Macedon.*

(7) *Occurrence of Columnar Structure.*—Mt. Conowrin displays columnar structure on a grand scale. The summit is inacessible, and consists of a mass of vertical trachyte columns. These are square in transverse section (Plate xlvi., fig. 2).

The Mountains Beerwah, Ngun Ngun, Tibrogargan, Cooee, Ewin and Tunbubudla all show a central plug of columnar trachyte similar to that of Conowrin. In the case of Ngun Ngun we find, in addition to a mass of squarish columns exposed on the S.E. side of the summit, that the main body of the mountain is composed of huge columns of coarse-grained trachyte, rather rich in iron-bearing constituents. These columns are polygonal in transverse section; they are vertical on the summit, but horizontal or inclined on the sides of the mountain. A study of the arrangement of the columns on Ngun Ngun somewhat strengthens the idea that some of these mountains are of the nature of mamelons.

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* Gregory, J. W. (and Grayson, H. J.), "The Geology of Mount Macedon, Victoria." Proc. Roy. Soc. Victoria. Vol. xiv. (New Series), p. 186, 1902.

Mt. Beerwah is also entirely columnar. On the N.W. side, near the summit, we see a mass of fine rectangular columns similar to those of Mt. Conowrin. Near the base, however, the columns are tabular, and do, as Mr. Stutchbury has already remarked, lean inwards.* The large tabular columns of Mt. Beerwah consist of a peculiar glistening and soft trachyte which superficially resembles sandstone, so much so that Mr. Stutchbury described them as metamorphic sandstone. They contain large phenocrysts of plagioclase up to $\frac{1}{4}$ inch in diameter. The sandstone outcropping in a gully east of Beerwah dips 25° in the direction of Conowrin.

(8) *Occurrence of Basalts in the District.*—Mt. Mellum is basaltic. Its height is over 1,200 feet, and from the 500 feet level to the summit we meet with basalt only. The mountain was scaled from the south-east along a ridge which consists of sandstone until a height of 500 feet is reached. The lower basalt (between 500 and 600 feet) is vesicular, as is also the basalt of the summit. Between the two masses of vesicular basalt we meet with, in the ascent, a thick mass of compact columnar basalt. At the junction with the sandstone we find the latter strongly metamorphosed—turned, in fact, into quartzite.

Basalt-flows from Mt. Mellum have once extended south beyond Coochin. They are now denuded except for isolated patches of basalt and scattered basaltic nodules, but they have impregnated the subjacent sandstones with iron, and turned the sandy soil bright red.

Mt. Mellum probably represents a basaltic extinct volcano. It seems to me unlikely that it represents a flow for the following reasons:—

1. In the ascent, horizontal columns only have been met with.
2. Its isolation and seeming freshness.

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* New South Wales Geological Survey. Fourteenth Trimonthly Report, dated Durandur, 1st August, 1854. Legislative Council Papers, N.S.W., 19th September, 1854.

Very little denudation has taken place since its period of activity, although the rock is very decomposable. Its distance from the nearest basaltic mountains of the Blackall Ranges is about five miles, and if it represents a remnant of a denuded flow from them, a mass of basalt over 800 feet in thickness has been removed in the valley between them. If that were the case, it is hardly imaginable that we should meet with such excellently preserved vesicular basalt on the very summit of Mt. Mellum.*

The balance of evidence, therefore, favours the supposition that it represents a volcano.

(9) *Situation of the Volcanic Mountains on Intersecting Groups of Cracks.*—By looking at the accompanying map (Plate xlvi.) it will be seen that the mountains of the Glass House group lie on intersecting cracks, having approximately the directions N. to S. and E. to W. The main fissure seems to be that on which Miketeebumulgrai, Tunbubudla, Conowrin and Mt. Mellum lie. Another line may be drawn in a nearly parallel direction through Beerburrum, Tibrogargan, Ngun Ngun, Coochin Hill and Mt. Mellum. At right angles to these two lines we find one passing through Beerwah, Conowrin and Ngun Ngun; a parallel fissure passes through Mt. Beerburrum and the two Tunbubudla mountains.

The dykes radiating from Tunbubudla may be looked upon as radial cracks caused by the lava outburst.

(10) *Age and Origin of the Glass House Mountains and adjacent Rocks.*—There is no evidence that the Glass House Mountains have been submarine in origin. There are no submarine tuffs; the holocrystalline nature of the trachytes, as well as the occurrence of large fragments without any definite orientation in the Trachyte Range tuffs, and the absence of definite arrangement of the crystals in these tuffs are evidence against submarine origin. In the trachytic lavas, too, we meet with but

* "Mellum" seems to be an aboriginal word for volcano. The mountain may have been active in the human period. Otherwise, why should the natives have given it the present name? Rumblings are said to have been heard under it last year.

few instances of vesicular structure, such as we should expect from the presence of much water, and no glassy rock, which would result from rapid cooling.

It is, however, likely that the sea was not far off at the time of the Glass House Mountain eruptions.

From the coarse-grained nature of the Triassic sandstones of the East Moreton district in the Glass House Mountain region and the abundance of fossil wood contained, it appears that these rocks were deposited in a wide estuary. Sedimentation may have lasted well into Cretaceous times, but so far no Cretaceous rocks have been identified in this region, though further north we have the Maryborough Beds overlying the Trias. When sedimentation ceased, the strata were elevated through rise of isogeotherms; at a somewhat later period—probably the end of the Cretaceous—recooling and denudation had progressed far enough to allow cracking of the sedimentary strata. Through cracks thus formed the Glass House trachytes found an exit. Subsequent folding of the topmost beds probably gave rise to the D'Aguilar Range and the Blackall Ranges, and this folding was probably accompanied by the andesitic and basaltic outpourings of lava.

In age the trachytes are probably Pre-Miocene. No definite proof of age has been obtained, but the amount of denudation which they have suffered and the almost total removal of tuff-beds and crater rings, if these ever existed, hint at considerable antiquity. The same lack of good evidence of geological age seems to hold for most Australian trachytes, but the consensus of opinion amongst our geologists, based on the small amount of evidence available, assigns to them a Cretaceo-Eocene age. This also seems to hold best for the Glass House trachytes.

The basaltic rocks of Mt. Mellum bear considerable petrological resemblance to those of Tambourine Mountain, described by Mr. Rands, late Government Geologist of Queensland.*

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* Jack & Etheridge, 'Geology and Palæontology of Queensland.'

Mr. Rands considers the Tambourine basalt to be Miocene or Pliocene, hence contemporaneous with many other Australian basalts. The Mt. Mellum rock is, if anything, later. The comparative freshness of this readily decomposable rock, the abundance of vesicular basalt, which is ever so much more readily disintegrated than hard columnar basalt, are reasons which justify us in assigning a late Tertiary, Pliocene or Pleistocene, age to Mt. Mellum.

In his paper already cited,* Mr. Andrews looks upon the Glass House Mountains as monadnocks, or hypabyssal masses left by the denudation of a Tertiary (Miocene) plateau into which the lavas had been injected. I cannot at present embrace that view, inasmuch as the D'Aguilar Range appears from my observations to be a Tertiary fold range, and not a remnant of a now-denuded plateau. Besides, the petrographical nature of the Glass House Mountain lavas and the occurrence of some tuffs in the ridge which is here named Trachyte Range, indicate that the rock is volcanic and not hypabyssal.

The upper sandstones of the East Moreton may be in part of Lower Cretaceous age, the Trias merging, as the Ipswich beds do, into the Cretaceous. The absence of later beds in the district can be explained on two hypotheses—either it has been dry land ever since Upper Cretaceous times, or repeated fluctuations causing periodical submergence have taken place. The latter supposition seems more likely to be correct, accounting satisfactorily for the absence of cliffs, escarpments, and other signs of great erosion. It seems the most natural conclusion to come to, that *moderately* stable conditions have prevailed in the Glass House Mountains area ever since the trachyte eruptions, and that the district has preserved its character as a low-lying coastal plain, occasionally submerged, but each period of elevation sufficing to remove the deposits formed in the period of sedimentation.

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* "Preliminary Note on the Geology of the Queensland Coast."

Greater denudation of the Triassic has taken place in the Blackall Range area, where sedimentation had been greater, and subsequently re-elevation more considerable.

That the eastern coast of Australia is undergoing a wave-like movement tangential to shore-line is rendered probable by the evidence afforded by numerous submerged forests and raised beaches along our coasts. Folding from the N.W. in New South Wales and from the S.W. in Queensland would explain such a tangential movement, the focus from which folding proceeds underlying the New England Tableland and the McPherson Range.*

Tidal action extends in the meandering Caboolture River as far as Wararbah Creek, and larger streams like the Caboolture and Stanley rivers have undoubtedly captured the drainage areas of other streams which are now represented by creeks and swamps. This indicates long-continued stable conditions, or at any rate *extremely slow* change of level. Sandy bars occur at the mouths of all the creeks and rivers. Yet it would be extremely risky to draw inferences from these features, as, on account of the soft nature of the Triassic bedrocks, and the vehemence of Queensland floods, it does not take a river very long to carve a course for itself in this region, and those rules which hold for hard Palæozoic formations can in this case only be applied with extreme precaution.

v. Petrology.

The subject of the petrography of the Glass House Mountains rocks, the writer proposes to discuss in greater detail in a future paper.

An idea has already been given of the sedimentary rocks of the district, which comprise :—

1. The Palæozoic slates and schists referred by Queensland geologists to the Gympie Formation.

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* *Cf.* Suess' Theory on "The Parallel Grouping of Mountains round Ancient Coasts" in 'Das Antlitz der Erde.'

2. The Triassic or Trias-Jura rocks, consisting of sandstones and conglomerates, with interbedded shales and mudstones.

The igneous rocks may be divided into Plutonic and Volcanic, the dyke rocks being best considered with one or other of these divisions.

(A) Plutonic.—To this division belong the granites, diorites, gabbros, gneisses and augen-gneisses of the coastal range. These ancient rocks form the core of the range, being flanked on the eastern side by the Palæozoic slates and schistose rocks. They are cut by dykes of aplite, ægerine syenite, hornblende rock, diabase, &c., as well as by quartz reefs and leaders, usually more or less metalliferous.

(B) Volcanic.—The volcanic rocks of the district fall petrologically under three heads—trachytes, andesites, and basalts.

(*i.*) *Trachytes.*—The Glass House Mountains proper are all composed of trachyte. To make clear the mineral constitution of the most typical rocks, it will be useful to consider first a few special cases.

Beerburrum Trachyte.—Hand specimens of this rock when freshly broken have a glistening white marble-like appearance. On decomposing the rock acquires a reddish, or dull brick-coloured tint. The glistening of fresh specimens is due to large crystals of sanidine, up to ½ an inch in diameter. The rock is seen to be coarsely porphyritic, and to consist almost entirely of felspar, ferromagnesian minerals being only revealed on examination with a pocket lens.

Microscopic examination showed that the base consisted of lath-shaped, felspar crystals, of the sanidine variety, and two varieties of hornblende; the one hornblende is deep brown to reddish-brown in colour, strongly pleochroic, and more plentiful than the other variety, which is a deep blue pleochroic hornblende, probably riebeckite. A colourless pyroxene, non-pleochroic and with strong birefringence, is also present in scattered irregular grains.

From faint traces of multiple twinning in the porphyritic felspar phenocrysts it was suspected that they were not true orthoclase. These crystals are twinned like sanidine on the Carlsbad plan, and have a refractive index of 1·525. Measurements of extinction angles and microchemical tests proved a fair amount of soda and a little lime to be present. Hence some, if not all, of these phenocrysts are composed of anorthoclase.

Hand specimens of Beerburrum rock resemble specimen No. 9256 (Trachyte from the Canoblas) in the Sydney Mining Museum.

Beerwah Trachyte.—The specimen sectioned was obtained on the N.E. flank of the mountain, and is typical of the bulk of the Mt. Beerwah rock. This trachyte separates on weathering into huge shingle-shaped slabs. It has a very glistening, silky lustre when freshly broken, apparently due to the habit of the constituent felspar. The rock is very soft and crumbling, and has a greenish-grey colour. It was taken by Mr. Stutchbury, in 1854, to be metamorphic sandstone, probably on account of its tendency to split into slabs and its comparative softness. With aid of a pocket lens the rock can be seen to be porphyritic, containing abundant tabular phenocrysts of a plagioclase felspar. A few hornblende phenocrysts are also present.

Examined under the microscope, flow-structure is very apparent, the arrangement being trachytic-pilotaxitic as in the typical trachytes of the Siebengebirge (Drachenfels type). Felspar is the predominant constituent, both as sanidine with characteristic cross cracking, and in form of a plagioclase felspar which seems to be oligoclase or andesine. The crystals are lath-shaped, with their long axes all in the same direction. The base is microcrystalline and displays the trachytic variety of pilotaxitic texture. No glass is present. The ferromagnesian minerals are a brown hornblende, often in well shaped, twinned crystals; a strongly pleochroic hornblende, having green, blue and slate-coloured pleochroism in different sections. This latter amphibole is probably arfvedsonite, and is frequently seen enveloping the brown hornblende which is barkevicite. Ægerine is scattered plentifully throughout the base in minute rods. The chief characteristics of this rock are: the typical trachyte lustre, trachytic texture, predominance of plagioclase felspar (probably andesine, with which it agrees best in optical properties), and the tendency of the rock as a whole to split in slabs.

A few deep red to brown, strongly pleochroic grains, answering to the description of cossyrite, were observed as a nucleus to a crystal aggregate of the green hornblende (arfvedsonite).

Conowrin Trachyte.—This is a white or greyish-white rock in which a pocket lens reveals scattered black specks. A few felspar phenocrysts are usually present. Some specimens show flow arrangement to the naked eye. This trachyte forms the fine rectangular columns of which Mt. Conowrin is entirely made up.

Microscopically examined the Mt. Conowrin rock is seen to consist almost entirely of sanidine. In fact the other constituents do not form 3% of the bulk of the rock. The texture is holocrystalline and orthophyric. The ferromagnesian minerals present include ægerine in minute green pleochroic rods; scattered crystals of a blue hornblende which in transverse section show strong pleochroism from deep green to deep blue; in longitudinal section some of the crystals appear perfectly opaque. This amphibole is probably allied to arfvedsonite or riebeckite. It is identical with the deep blue pleochroic hornblende in the trachytes of Mount Jellore. near Mittagong, recently investigated by Messrs. Mawson and Taylor. This hornblende was the first mineral to crystallise from the magma, occurring often as inclusions in the centre of a sanidine phenocryst. Its crystalline form is never preserved, corrosion and resorption having taken place. A colourless non-pleochroic pyroxene is present in a few very minute grains.

A section made of a specimen of trachyte from the dyke at the landslip on the W. side of Conowrin is somewhat different in mineral constitution. The amphibole with the strong absorption in one direction is absent, and its place is taken by very numerous minute, acicular crystals of an olive-green colour. They are pleochroic in brownish and green tints. A few good crystals of a greenish-brown hornblende (allied to barkevicite) are present.

This is sometimes twinned. A few grains of riebeckite were present.

The rock from Mt. Ewin is macroscopically like that of Conowrin, but microscopically it was observed that the ferriferous constituents had taken chiefly the form of ægerine. A few phenocrysts of a brownish hornblende were also present (barkevicite).

Mt. Ngun Ngun Trachyte.—The main mass of Mt. Ngun Ngun is built up of huge polygonal columns of porphyritic trachyte. Specimens from here are macroscopically very like specimen No. 11227 (Trachyte from the Canoblas, Orange) in the Mining Museum, Sydney. The rock is holocrystalline, consisting of sanidine phenocrysts which are sometimes corroded, and a microcrystalline orthophyric base. The base contains sanidine, scattered irregular granules of a colourless non-pleochroic pyroxene, and the green pleochroic hornblende often with a nucleus of brownish hornblende. Fragments of quartz are present as an accessory, and also a few fragments of an orange-yellow mineral. The quartz is probably allogenic, derived from the sandstone in the upward passage of the magma. Another variety of trachyte is found on the S.E. side of Ngun Ngun; this is exactly similar in structure to that of Mt. Conowrin. There is also a third variety found on the E. side of the mountain; this rock is of a bluish-grey colour, very hard, and emits a ringing sound when struck. In section it was found to be composed of sanidine in phenocrysts, lath-shaped sanidines, and deep blue hornblende and green ægerine in the base.

Round Mountain Trachyte.—Hand specimens of this rock are often much darker in colour than usual, so as to suggest a fine-grained andesite. But the darkness is entirely due to mineral solutions which have permeated the rock after its formation. Sections prove the Round Mountain rock to be a holocrystalline trachyte, very fine in texture, but containing a few small sanidine phenocrysts scattered in a microcrystalline to cryptocrystalline base. The rock consists almost entirely of sanidine felspar, ægerine in minute granules, and a few scattered crystals of the deep blue hornblende (riebeckite) which has also been noticed in some of the fine-grained Conowrin rock. The phenocrysts of sanidine are frequently strongly arched, having evidently been subjected to very great pressure in the upward passage of the magma. The sanidines are twinned on the Baveno, Carlsbad, and Manebach laws.

Some of the hand specimens of Round Mountain trachyte are not unlike specimen No. 10559 (from ¾ mile N. of Tondeburine Ck., Warrumbungle Mts.), Mining Museum, Sydney.

Mt. Cooee Trachyte.—The rock composing Mt. Cooee varies widely in macroscopic appearance. Some is dark-coloured, coarsely porphyritic, and resembles the andesitic rock of Grigor's Estate, into which it seems to merge. The specimen sectioned was of a bluish-grey colour; this rock forms irregular columns, and weathers into rounded boulders. It is comparatively rich in quartz, which occurs in large crystals easily seen with the naked eye. In colour and texture this rock resembles specimen No. 11215 from Orange, in the Sydney Mining Museum.

The constituents of the quartz trachyte are sanidine—the most abundant component—a considerable amount of quartz, and a small proportion of dark blue hornblende. The central part of Mt. Cooee consists of square columns similar in colour, size and shape to those of Mt. Conowrin and Mt. Ewin. Whether the quartz-trachyte, quartz-andesite, and true trachyte of this mountain are contemporaneous or not, and whether they are derived from the same magma, I have not yet been able to determine; but the order of superposition in places where superposition could be ascertained, is—(1) trachyte, (2) quartz-trachyte, and (3) quartz-andesite.

Trachyte Range Rock.—This rock is a true pyroclastic rock or tuff. It is of a dark green colour, very hard, and emits a ringing sound when struck; it also contains angular opaque fragments of a dark colour. Under the microscope it is seen to consist of crypto-crystalline and amorphous material, forming a base containing scattered sanidine crystals and angular fragments. The substance of the base is in the form of minute needles and granules, and is chiefly felspar, a darker green mineral being also present in fine needles. This is probably acicular microlites of ægerine. Glassy material seems also to be present.

True trachyte lavas also occur on Trachyte Range, forming the summits of the ridge. They resemble the rock of Mt. Ewin. One specimen obtained on the southern side of the ridge is macroscopically very like specimen No. 5006 (Riebeckite Trachyte, Warrumbungle Mts.), in the Mining Museum, Sydney. Microscopically examined, it is seen to consist of a holocrystalline, even-textured sanidine ground-mass, containing peculiar dark blue to black, arborescent aggregates of ultra-microscopic crystals, probably a hornblende, arfvedsonite or riebeckite.

The trachytes of Mt. Miketeebumulgrai are partly fine in texture like that of Mt. Conowrin, and partly coarse and porphyritic like that of Mt. Beerburrum.

Mt. Tibrogargan is composed of trachytes of a fine texture, resembling those of Mt. Conowrin and Mt. Ewin. They seem to be essentially ægerine trachytes.

To sum up and generalise, it might be said that most of the Glass House Mountains are composed of columnar trachyte. The core of the mountain usually consists of vertical columns, and the sides often of horizontal and slanting columns (*e.g.*, Ngun Ngun and Tibrogargan). The trachyte rocks are usually of a grey colour and dull lustre. The more porphyritic trachytes (*e.g.*, Beerwah, Beerburrum, Ngun Ngun) contain more brown and greenish blue hornblende (barkevicite and arfvedsonite) than the more even-textured rocks. The hornblendes seem to have been the first mineral to crystallise, being usually very corroded, and often occurring as inclusions in sanidine phenocrysts. The sanidine phenocrysts are often corroded and partially resorbed; they possess the characteristic cross cracks parallel to the (100) plane. In the instance of the Beerburrum rock, the phenocrysts proved to be anorthoclase, containing a considerable amount of soda and some lime. In the coarsely porphyritic rocks ægerine is less plentiful than hornblende. The amphibole sometimes occurs in twinned phenocrysts.

The more fine-textured trachytes, such as those of the Round Mountain, Mt. Conowrin, Mt. Ewin, and Mt. Tibrogargan contain a greater proportion of ægerine and less hornblende. Occasionally crystals of deep blue, highly pleochroic riebeckite are present. The main constituent of all the trachytes, both coarse and fine, is felspar, anorthoclase, with sanidine (orthoclase) in the Beerburrum rock, andesine or oligoclase and sanidine in the Beerwah rock (the plagioclase being here the more abundant constituent), and sanidine, with or without some anorthoclase, in the other rocks; the more basic minerals form but a minute portion of the bulk of the rock. The hornblendes seem all to be soda-bearing varieties, strongly pleochroic and deep blue, green or greenish-brown, possessing strong absorption in certain directions, being allied to the species riebeckite, arfvedsonite, barkevicite, and cossyrite (?). The augite is chiefly a soda-bearing variety, ægerine, in rods and needles.

Pilotaxitic and *trachytic* textures are seen in the rocks of Mt. Beerwah, Round Mountain and in some of the Conowrin rock. A *microrthophyric* base obtains in most of the other trachytes.

Holocrystallinity is univeral in the trachytes, but the grain size of the base varies from cryptocrystalline to microcrystalline. Porphyritic structure is also prevalent.

The felspar phenocrysts are usually somewhat corroded, though sometimes perfectly idiomorphic; hence the felspar seems to be of *two generations*, partial crystallisation having taken place in a subterranean reservoir, leading to the formation of the blue hornblendes with strong absorption, the deep green hornblendes (arfvedsonite), and many of the felspar phenocrysts. Partial resorption has taken place in the upward passage of the magma.

Zoning is common in the idiomorphic felspar phenocrysts.

(ii.) *Andesite (Dacite) Formation at Grigor's Place.*—This lava varies immensely in composition, texture, colour, &c. It covers an area of about one square mile, lying between Beerwah, Conowrin, Tibrogargan and Ewin. The colour of the rock is for the most part dark grey to black, but in the close vicinity of Bankfoot House we find it—

(1) Green, hard, compact without fragments.

(2) Red, soft, not unlike a tuff (weathered sp.).

(3) Dark brown, basaltic-looking.

(4) Grey, with huge black fragments, and quartz phenocrysts.

(5) Nearly black, with fragments and quartz phenocrysts.

These different kinds of rock all form part of one flow, and merge into one another. Some specimens are quite rhyolitic in appearance, some trachytic, some dacitic, and some very basic. In some places the lava has developed a pseudo-columnar structure, and has rendered the underlying sandstones columnar. Slides examined show the following constituents to be present in the blackish and commonest type of rock composing this flow :—

(*a*) Felspar. Plagioclase showing fine optical zoning and shadowy extinction, twinned on the Carlsbad, Albite and Pericline laws, is plentiful. The more basic interior is probably labradorite, and the less basic exterior andesine. Some orthoclase is present, also showing zoning (perhaps anorthoclase).

(*b*) Quartz is present in corroded crystals, with glassy inclusions. In some specimens it is very abundant.

(*c*) A variety of light green, faintly pleochroic augite in large crystals; extinction angle 34° to 56°.

(*d*) Hornblende of two varieties, one of a brown colour with characteristic cleavage, and one green fibrous variety.

(*e*) Magnetite is present as an accessory, and also a large amount of glass with inclusions and incipient crystals showing a fluidal arrangement.

(*f*) Green chloritic decomposition products are also present.

(*g*) Inclusions of trachyte are present. Some specimens sectioned contain inclusions of a plagioclase trachyte like that of Beerwah, with well marked pilotaxitic texture; one specimen obtained at Mt. Bokay contained an inclusion of Conowrin trachyte. These inclusions are important as affording evidence on the order of eruption of the lavas.

(*h*) Black, opaque, angular fragments are also present as inclusions.

Another specimen of the andesite formation, macroscopically of green colour and moderately fine texture, consisted of a pale hornblende (like edenite), a greenish glass, some magnetite, quartz, orthoclase, plagioclase and a little biotite. The pale green hornblende was the chief constituent.

(iii.) Mt. Mellum Basalts.—The basalts of Mt. Mellum bear close resemblance to the amygdaloidal basalts of Tambourine Mountain, described by Mr. Rands.

Mr. Rands describes the Tambourine basalts as amygdaloidal on the upper surface, generally full of olivine phenocrysts; and occasionally columnar, the columns being often 20 feet in length, and hexagonal in section.

The Mellum rock is in part vesicular, in part columnar. It contains large phenocrysts of olivine, plagioclase and black augite. The vesicular basalt occurs at the lowest and highest levels of the basalt. The rock is very *rich in olivine*; a dark red olivine (iron olivine, fayalite) is also present, and has taken the place of magnetite. *Fayalite* occurs sometimes as a nucleus to ordinary olivine, and was evidently the first mineral to crystallise. *Ilmenite* is present in tabular crystals, sometimes passing into leucoxene. The *augite* crystallised simultaneously with the *plagioclase*, the two minerals being intergrown. The augite seems to be titaniferous. The plagioclase agrees well in properties with andesine.

(c) OTHER ROCKS.—At the base of the Round Mountain, on the S.E. side, there is an outcrop of *aplite*, which probably marks the position of an outlier of palæozoic igneous rock. This aplite consists of quartz, orthoclase and plagioclase. Hand specimens are brick-red, and look like metamorphic sandstone. The mineral staining of the Round Mountain trachyte is probably connected in some way with this aplitic mass.

On the western side of the D'Aguilar Range at Butler's Creek, there are dykes of *ægerine syenite* traversing the granite. Recently, through the kindness of Professor David, I have had an opportunity of looking over a large number of specimens collected by Mr. J. M. Newman, B.E., at the Blacks' Reserve, near Woodford.

The country around Woodford is granitic. Mr. Newman obtained specimens of granite (both coarse and fine), gneiss, diorite, graphic granite, pegmatite (in veins), diorite, syenite and basic rocks. A dyke of basic rock like hypersthene anorthite gabbro, and a dyke of hornblende andesite composed almost wholly of hornblende, also occur here, intruding the granite.

vi. Other Australian Trachytes.

Professor Gregory has lately described an interesting series of Geburite-Dacites and Trachy-Phonolites occurring at Mount Macedon, Vic.* They seem to have many features in common with the rocks of the Glass House Mountains district.

The rocks of the Warrumbungle Mountains are recorded as trachytes by Professor T. W. E. David, who obtained there not only numerous specimens of trachytic lavas, but also tuffs interbedded with the trachytic magmas. In Wantialable Creek they overlie and are in part interbedded with diatomaceous earth and shales containing Cinnamomum leaves. The entire group of the Warrumbungle Mountains is known, through Professor David's researches, to form the wrecks of former trachyte volcanoes, and to consist of coarsely crystalline trachytic rock and interbedded tuffs.†

The trachytic heights of the Canobolas, near Orange, have lately received a great deal of attention and patient investigation by Messrs. Süssmilch and Curran, and it seems probable that these will prove to correspond in age and particulars to the other Australian Trachyte areas.

In Tasmania rocks analogous to our Australian trachytes have been discovered at Port Cygnet. They are chiefly Sölvsbergites, as are also some of the Mount Macedon rocks described by Prof. Gregory, of Melbourne. No definite flows have, so far, been

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* Proc. Roy. Soc. Vic. Vol. xiv. (New Series), pp. 193, 197.

† "Note on the Occurrence of Diatomaceous Earth at the Warrumbungle Monntains, N.S.W." Proc. Linn. Soc. N.S. Wales, 1896.

found (*cf.* The Glass House Mountains, *ante*); in structure they are coarsely porphyritic, another point of resemblance to many of the Glass House Mountains lavas (*e g.*, Beerburrum, Ngun-Ngun). Fayalite-melilite basalt occurs not far away, at One-Tree Point, and has been described by Mr. Twelvetrees. Similarly in the Glass House Mountains area we have the Fayalite basalt of Mt. Mellum. The age of the Port Cygnet trachytes is Upper Cretaceous or early Eocene, approximately the same as that of the Mount Macedon rocks.

The trachytic lavas and the syenites of the Mittagong district have also during the last eighteen months received very thorough investigation at the hands of Messrs. Mawson and Taylor, of the Sydney University.* The Gib Rock syenite and neighbouring trachytes have been shown by them to be probably Upper Cretaceous, at all events Post-Triassic and Pre-Tertiary. In chemical composition they have found it to be exceedingly rich in alkali (Mawson).

At Port Mackay, in Queensland, trachytic tuffs are described by Mr. A. Gibb Maitland as abundantly interstratified with Desert Sandstone of Upper Cretaceous age.†

At Yeppon, near Rockhampton, Q., a range of trachytic mountains occurs.

A large number of steeply conical mountains are interspersed with more gently sloping (probably basaltic) mountains in low-lying country south of the railway line between Brisbane and Helidon (Main Southern Line). Many of these may yet prove to be syenitic or trachytic in nature.

Mr. Rands describes a mass of trachytes containing beautifully developed sanidine crystals as occurring in railway cuttings between Logan village and Beaudesert, near Walton Station. They seem to have come up through the Ipswich Coal Measures

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* Paper read before Royal Society, New South Wales, October 7, 1903.

† "Geological Features and Mineral Resources of the Mackay District." By Authority: Brisbane, 1889. Also Jack & Etheridge, *op. cit.*, Text pp. 546-547, 1892.

and to have flowed over a portion of them. A similar rock is described about one mile west of Walton village, apparently interbedded with the Ipswich Coal Measures. Mr. Rands is uncertain whether it is intrusive (laccolitic) or interbedded. The former supposition is probably correct.*

All the Australian trachytes that have been chemically investigated are very rich in alkali, particularly soda. The Glass House Mountains trachyte probably will not prove an exception. Some specimens of Conowrin rock consist almost entirely of sanidine, but the Beerwah trachyte we find to be rich in plagioclase. The Mt. Mellum trachyte, like that of One-Tree Point, Tas., which is soda-bearing, contains an abundance of plagioclase and fayalite.

vii. Miscellaneous Notes.

The tendency of the Glass House Mountains to lie on linear fissures can be readily observed from one of the most southerly or northerly members of the group, *e.g.*, Round Mountain or Coochin Hill. Standing on the former height, one can get an excellent idea of the shape of the area on which the Glass House Mountains lie, as well as of their linear arrangement. From this point, fourteen or fifteen summits can easily be made out.

In connection with the question of cross-cracking, it is interesting to note that Mt. Mellum, Mt. Blanc and Candle Mountain, south of the Blackall Ranges, are three isolated peaks situated on a straight line running east to west parallel to the fissure on which Beerwah, Conowrin, and Ngun-Ngun are situated. Whether Mt. Blanc and Candle Mountains are basaltic or not, I have not been able to ascertain; but I am informed that the soil in the vicinity of them is very rich, hence it is safe to conclude that they are basaltic like Mount Mellum. The Blackall Ranges extend from Conondale east almost to the railway line, being approximately parallel to the two above-mentioned east and west fissures. Thence the range takes a northerly trend, becoming practically a continuation of the D'Aguilar Range, and running

* Jack & Etheridge, *op. cit.* p. 350.

parallel to the main north and south fissure of the Glass House Mountains. Basalt-flows, producing fine rich soil, have taken place from many points along this range.

The basaltic mountains of the East Moreton are easily distinguished from those composed of trachyte by the pretty gentle slopes, and rich tropical vegetation of the former. The Bankfoot House andesites seem to have been very fluid, much more so than the Mellum basalts. They have not given rise to any cones, but have flowed over sandstone formation and small trachyte outcrops alike.

In connection with the question of land-formation by the sea in Moreton Bay is the possible explanation of the shell-banks inland on the hypothesis that the sea has piled up bank after bank and thus retreated; Mr. H. L. Kesteven writes as follows:—

"During September, 1902, I had the opportunity of going through Bribie Passage and of examining in a cursory manner the country on either side of it. The 'Passage' runs between the mainland and Bribie Island. This island is wedge-shaped, about 17 miles long, and $3\frac{3}{4}$ miles broad at its broadest, southern, end; the greater part of it is but three or four, nowhere is it above 15 feet high. Its higher parts are blown (?) sand, and the lower black sandy mud. I was busy collecting mollusca, so did not have an opportunity of going over it thoroughly, but there is, I believe, no rock on the island anywhere. North of the high land at Toorbul Point, the mainland is of the same character.

"Some very interesting light was thrown on the growth of this low-lying country by Mr. C. Tripcony, in whose boat I went up the Passage.

"Owing to the strong current in the Passage, the bottom is continually shifting and changing the channel; the troubles of navigation were the subject of much conversation. Mr. Tripcony has owned oyster-beds in and sailed up and down the Passage for about twenty-five years. In the course of conversation, he pointed out to me an islet about two feet high at high tide, which he assured me did not exist in his early days on the Passage; on another occasion he drew my attention to some mangroves just showing above the water, and told me he had sailed over that spot, and that in a few years there would be dry land there.

"The mode of growth of this low-lying land, then, has been as follows:—

"(The shallows of the Passage are covered with lightly rooted marine grasses and weeds.)

"Back-waters or cross currents pile up a bank or shallow, the heavy mangrove seeds settle and take root. The mangrove once having taken root, not only puts its branches above the water but its roots above the soil. Anyone who has walked under a mangrove tree will remember that for yards round its trunk there are hundreds of spikes, a few inches long, sticking up from the soil in which it is growing.

"Here, then, we have a natural rake; the numbers of closely placed trees stop all that floats on the surface, while their roots stop heavier rubbish (loosened weeds) and sand moving along the bottom. Once our embryonic island reaches high-water level the rank grasses of the district take a hold and do their share of raising its height. Masses of matted grass roots, retaining soil, eighteen inches to two feet in thickness are frequently met with on the beach outside the northern end of Bribie Passage."

viii. Conclusion.

The present work was undertaken partly on account of the great lack of definite knowledge as to the geology of the Glass House Mountains, the views of different authorities varying within such wide limits; and partly to try to assist in the task of investigating and correlating the Australian trachytes. As shown in the part dealing with "Other Australian Trachytes," the work has been energetically tackled in Tasmania, Victoria and New South Wales by able investigators, whereas the Queensland trachyte areas have remained for the most part untouched, though of equally great importance and interest.

I am fully aware of the difficulty of the task I have undertaken. In a preliminary paper like the present it is impossible to deal with the subject so thoroughly as could be desired. Many problems remain untouched, and many of the interpretations given in the present paper may not be upheld by future investigators. I hope to continue the research by degrees, as opportunities arise, and other investigators may join. At all events it is hoped that this paper may prove a beginning in the thorough investigation of the geology of the Glass House Mountains.

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EXPLANATION OF PLATES.

Plate xlvi.

Map of the Glass House Mountains District.

Plate xlvii.

Fig. 1.—Portion of Mt. Conowrin, showing columnar structure.

Fig. 2.—Mt. Beerwah.

Plate xlviii.

Fig. 3.—Mt. Conowrin, showing the inaccessible portion of the mountain, consisting entirely of vertical trachyte columns.

Fig. 4.—Mt. Tibrogargan, as seen from a railway train.

Plate xlix.

Fig. 5.—Portion of railway cutting near Beerburrum Station, showing trachyte dyke causing an anticline.

Plate l.

Fig. 6.—Bird's-eye view of the Glass House Mountains from Mt. Ngun Ngun.

Fig. 7.—Bird's-eye view of the Glass House Mountains from Mt. Mellum.

(Figs. 1-7 are from photos by Mr. L. C. Ball, B.E., of the Geological Survey of Queensland, and are reproduced by permission).